

Appendix A

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158	160	162	164	166	168	170	172	174	176	178	180	182	184	186	188	190	192	194	196	198	200
3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165	168	171	174	177	180	183	186	189	192	195	198	201	204	207	210	213	216	219	222	225	228	231	234	237	240	243	246	249	252	255	258	261	264	267	270	273	276	279	282	285	288	291	294	297	300
4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200	204	208	212	216	220	224	228	232	236	240	244	248	252	256	260	264	268	272	276	280	284	288	292	296	300	304	308	312	316	320	324	328	332	336	340	344	348	352	356	360	364	368	372	376	380	384	388	392	396	400
5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230																																																						

RX-AVC: Automatic Volume Control Algorithm

(Internal distribution only)

1 Background

The RX-AVC is an advanced audio function that automatically controls the received speech level and dynamic range. The AVC is a collection of 3 functions. The 3 functions can be activated both separately and together. The 3 functions are:

1. Automatic gain control (AGC)
2. Automatic volume increase and dynamic range compression (DRC) as a function of TX noise level
3. Dynamic range compression (DRC) for speakerphone

The following block diagram shows how the RX-AVC fits within the other speech modules in the RX and TX paths.

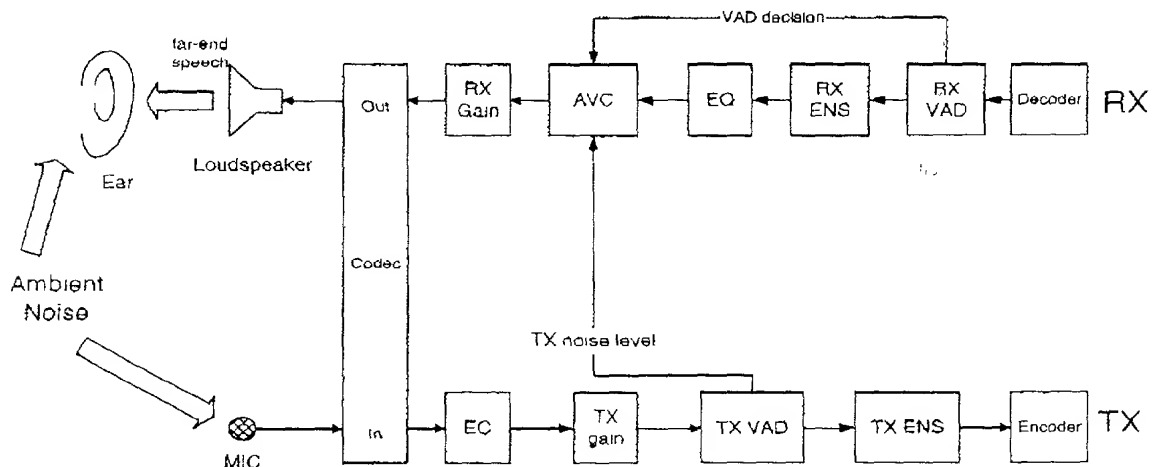


Figure 1: Audio path with RX-AVC.

2 Algorithm description

The total AVC gain is the sum of 3 gains:

1. AGC
2. DRC gain weighted by a maximum between two numbers: (1) a weight proportional to the TX noise level, (2) DRC GAIN FACTOR.
3. Additional constant gain whose value is weighted by TX noise level

Enabling flags (AGC_FLAG and NOISE_RESPONSE_FLAGS) gate the AGC and the noise-weighted gains. Figure 2 shows the algorithm block diagram.

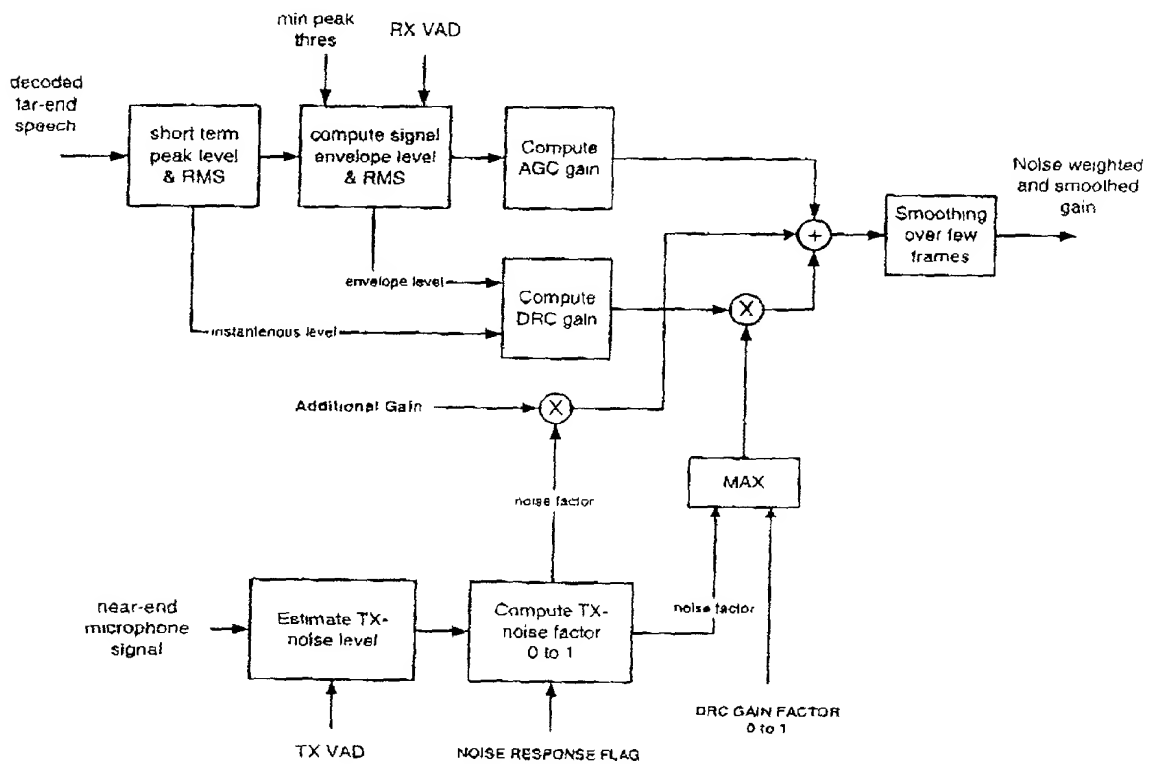


Figure 2: block diagram

2.1 Blocks description

2.1.1 short-term peak & short-term rms level

Computes maximal sample energy over a sub frame several samples (default=16)

Computes rms energy over the sub frame

2.1.2 Compute signal envelope level & speech-RMS

Envelope is updated if RX-VAD detected speech and if the local peak is above a threshold:

```
if (RX-VAD && local_peak > MIN_ENVELOPE)
{
    if (local_peak > envelope)
        envelope = min(local_peak, envelope + INCREMENT_PEAK) ;
    else
        envelope -= DECREMENT_PEAK ;

    if (rms > long_term_rms)
        long_term_rms += INCREMENT_RMS ;
    else
        long_term_rms -= INCREMENT_RMS ;
}
```

2.1.3 Compute AGC gain

Basic relation: $agc_gain = (LEVEL1 - envelope)$;

Limitation 1: $agc_gain = \min(MAX_AGC_GAIN, agc_gain)$;

Limitation2: $agc_gain = \min(MAX_RMS - long_term_rms, agc_gain)$;

2.1.4 Compute DRC gain

Given the following noise dependent and RX- signal independent parameter:

$drc_gain = MAX_DRC_GAIN * \max(drc_gain_factor, noise_factor)$;

Compute for each sub-frame the following gain (frame_drc_gain) as a function of its local peak and the envelope level as depicted in the following figure:

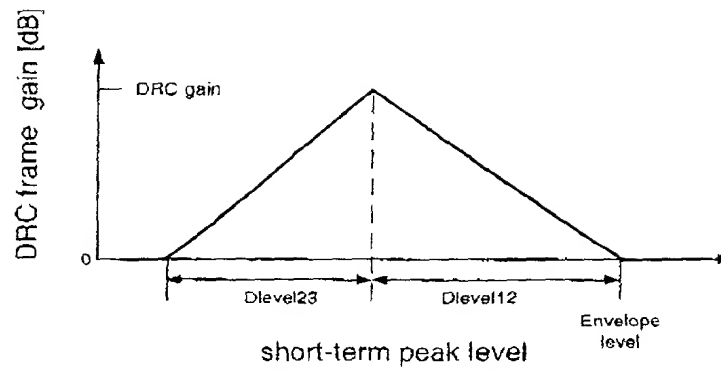


Figure 3: DRC gain function

2.1.5 Estimate TX noise level

See Period_alg.doc

2.1.6 Compute Noise factor

Noise factor is a function of noise level

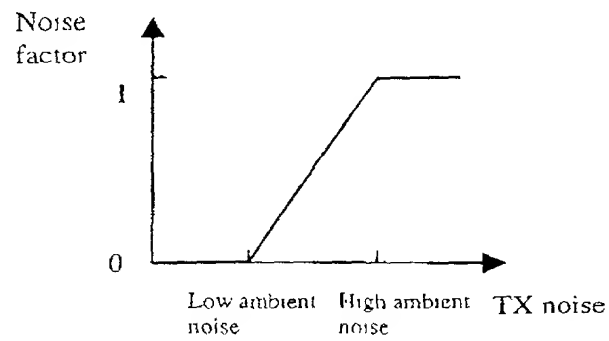


Figure 4: Noise factor

2.1.7 Gain smoothing

Signed exponential smoothing:

```
if (target_gain > smooth_gain_db)
    alfa = ALFA_UP ;
else
    alfa = ALFA_DOWN ;

smooth_gain_db = smooth_gain_db * (1-alfa) + alfa * target_gain ;
```

3 Parameters

3.1 Tunable parameters

AGC_FLAG

AGC enable/disable control bit

NOISE_RESPONSE_FLAG

Enable/disable control bit for the ambient noise-induced automatic volume increase.

DRC_GAIN_FACTOR

Controls the amount of DRC, ranging from 0 to 0x7FFF. Default = 0.

LEVEL1

Target level for the RX-signal envelope level. Default value: -3 dBov (3 dB below clipping level).

HIGH/LOW_AMBIENT_NOISE:

See figure 3. The default values are -39 dBov (low) and -21 dBov (High). Increasing these thresholds will reduce the effect of the RX-AGC to noise. The thresholds should be modified if the TX analog path gain is changed. For example, if the TX analog codec gain is increased by X dB, these thresholds should be increased by the same X dB.

MAX_AGC_GAIN

Upper limit on the AGC gain in the module "Compute AGC gain" (see 2.1.3). The default value is set to 21 dB.

MAX_DRC_GAIN

Upper limit on the DRC gain in the module "compute DRC gain" (see 2.1.4). The default value is set to its maximum allowed value of 21 dB. Decreasing this parameter will decrease the effect of the DRC.

MAX_RMS

The AGC gain is limited so that the signal RMS after amplification does not exceed MAX_RMS (default = -15 dBov).

MIN_ENVELOPE

Signals whose envelope is smaller than this threshold do not affect the AGC

3.2 *Soft constants (default)*

NUM_SUB_FRAMES	(10)
SUB_FRAM_LEN	$(\text{FRAM_LEN}/\text{NUM_SUB_FRAMES} = 16)$
LOG_SUB_FRAM_LEN	$(10 * \log_{10}(\text{SUB_FRAM_LEN}) = 12)$
DLEVEL12 (see Figure 3)	(24)
DLEVEL23 (see Figure 3)	(26)
DECREMENT_PEAK	$(3 * \text{SUB_FRAM_LEN}/8000 = 3 \text{ dB/sec})$
INCREMENT_PEAK	$(1 = 1 \text{ dB/sub_frame})$
INCREMENT_RMS	$(10 * \text{SUB_FRAM_LEN}/8000 = 10 \text{ dB/sec})$
ALFA_UP (see 2.1.7)	0.1
ALFA_DOWN (see 2.1.7)	0.5